REGULAR EXERCİSE, L-CARNİTİNE AND DİABETES TYPE II

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Abstract

Physical activity, regular exercise and physical fitness affect human life to live healthier and longer than normal. Physical activity deficiency is now quite common in the adult and elderly population. Combined with the increasing inactivity of the needs of most business sectors in a sitting position or the prolonged time at the computer, it shortens the physical activity of individuals. This physical activation deficiency in individuals is also of great importance in health problems caused by inactivity. One of the biggest health problems caused by lack of physical activity is diabetes type II disease. Diabetes disease is a metabolic disease caused by insufficient insulin secretion of the pancreas or impaired response of tissues to insulin, affecting protein, fat and carbohydrate metabolism. The most important sign of the disease is hyperglycemia. L-carnitine is a derivative of lysine and methionine amino acids. Carnitine is first synthesized in the liver and kidneys in our body, then it can be transferred to other tissues. L-Carnitine increases non-oxidative glucose excretion and increases the effect of carnitine on glycogen storage in euglycemic hyperinsulinemic conditions in healthy people and type 2 patients with diabetes. L-Carnitine administration improves insulin-stimulated glucose excretion and shows that the metabolite has worked at the interface between fatty acid metabolism and glucose metabolism. As a result, regular exercise and physical fitness of people are in good condition, significantly preventing the risk of people getting type II diabetes and also eliminating the risk factors associated with type II diabetes. The use of L-carnitine positively affects the course of the disease in people with type II diabetes. As a result of these results, the use of L-Carnitine in diabetes type 2 patients may be recommended in combination with physical activity and regular exercise under expert control.

Keywords: Regular exercise, Physical activity, Type 2 diabetes, L-Carnitine

Introduction

While people have been doing their work using their own bodies for years and even centuries ago, today they have moved away from a lively lifestyle with the development of technology and the opportunities that technology offers to people. In most countries today, gaining a lively lifestyle has become the primary issue of states. Because it is a scientific evidence that maintaining health and living a healthy life with exercises is not a dream. It is known that the findings obtained with medical methods (drug therapy, surgery, etc.) are not satisfactory when compared with the efforts, money spent and time allocated for these medical methods. However, it will be possible to prevent billions of lira spent on healthcare with 10-15 minutes of exercise every day (18).

Material and Method

Collection of Data

The research was conducted with document analysis and scanning model. Literature review covers the analysis of written materials containing information about the phenomenon or phenomena aimed to be investigated by document analysis. In the

research, the literature on Physical Activity, Regular Exercise, L-Carnitine and Type II Diabetes was conducted.

Data collection tool

In making this scientific review, local and foreign literatures have been carefully scanned in order to make the review reliable and comprehensive. In the literature search, reliable science-based indexes were scanned, including Elseiver, Springer, Google Scholar, Pub Med, Med Gen, Tübitak, Yök National Thesis Center and Journal Park.

Data Analysis

Qualitative data analysis is a process where the researcher organizes the data, divides it into analysis units, synthesizes it, reveals forms, discovers important variables, and decides what information to reflect on the report. In other words, the researcher conducting qualitative analysis tries to discover and reveal the information hidden in these data, based on the data he has collected from the field. For these purposes, the works, articles and researches written about Physical Activity, Regular Exercise and the relationship of L-Carnitine with Type II Diabetes have been scanned, examined and interpreted.

Results

Physical Activity and Regular Exercise

In our daily routine life, movements made with the help of muscles, bones and joints as a result of the consumption of energy, the increase of the speed of the heart and respiratory system and with different intensities are applied with different intensities, and as a result, movements ending with fatigue are expressed as physical activity. Examples of these physical activities are running, walking, jumping, cycling, swimming, head-neck and arm-leg movements, or some sports that involve all or less of the basic body movements, dancing, exercise, games and days. We can say it as the physical activities in it.

Regular exercise is an important factor in the physical readiness of the body. Physical fitness affects human life in two ways, in a healthier and longer life than normal. First of all, it significantly reduces the risk of physical, fitness, standard weights and cardiovascular and circulatory system disorders. Secondly, the person with condition has more body reserves that can be used when he / she becomes ill. (12).

Physical activity deficiency is now quite common in the adult and elderly population. There are many behavioral, spiritual and physical reasons why people choose a lifestyle without physical activity or do less physical activity. In Turkey, the limited extent that the people of the time, the less physical activity than it should have been among the reasons for the almost the most we face (7).

In the last century, the level of physical activity performed alone has decreased significantly. Most of the business sectors' sitting position requirements or the prolonged time at the computer, combined with the increased inactivity, shorten the physical activities of people over time. It is of great importance in jobs where people have such working environments, and health problems caused by lack of physical activation (5).

One of the biggest health problems caused by lack of physical activity is diabetes type II. First of all, a less than necessary and irregular diet combined with a stagnant lifestyle also enables a major health cause such as diabetes to come to light (17).

Table 1: Relationship between physical activity and some health problems (15).

Disease	Risk Reduction	Symptom Reduction	Result Improvement	Exercise Type
Alzhaim is	+			**0**
Anxiety	++	++	+++	**0**
Asthma	+	+		**0**
Chronic Heart Diseases	+++	+++	++	**0-E**
Heart attack	+	++	++	**S-0**
Breast Cancer	++	+	++	**0**
Colon cancer	+++	++	++	**0**
Endometrial Cancer	+			**0**
Lung cancer	+			**0**
Prostate cancer	+	+	++	**0**
Depression	++	++	++	**0**
Diabetes Type 2	+++	+++	+++	**0-E**
Hypertension	++		+++	**0-E**
Longevity		+++	+++	**0**
Obesity	++	++	+++	**E-0**
osteoarthritis		+	+	**S-0**
Osteoporosis	++			**S(W)-0**
Peripheral Vascular Disease		+		**0**
Pregnancy		+	++	**0**
Cigaret	+	++	++	**0**
Stress	++	++	++	**0**
Ulcer	+			**0**

+: Low Efficacy, ++: Moderate Effect, +++: Highly Effective **0**: Moderate Activity, **E**: Energy Expended Exercises, **S**: Strength Exercises, **W**: Weight Exercise

L-Carnitine

Structure with L-Carnitine Definition

L-carnitine is a derivative of lysine and methionine amino acids. L-carnitine was previously named as vitamin BT because it behaves like a vitamin in flour moth (Tenebrio molitor). Although it has recently been widely known as the BT vitamin, this nomenclature is not completely correct. The reason is that humans and other multicellular organisms can synthesize carnitine endogenously. However, in some special diets (pregnancy, infancy), carnitine is a small nutrient that must be taken into the body (16).

Carnitine palmitoyltransferase-1 is a transmembrane protein located on the outer mitochondrial membrane where it catalyzes the conversion of acyl-coenzyme A esters to acyl-carnitine esters (31).

In another definition, L-carnitine is a nutritional element related to B group vitamins, like amino acids or vitamins. Its main importance is it is an essential element in the conversion of fatty acids into energy (28).

"Carnitine is chemically formula β-hydroxy-γ-trimethylaminobutyrate. The carbon chains and nitrogen in its structure come from L-lysine, and methyl groups come from methionine. L-carnitine exists in humans in free and esterified form. Free carnitine (L-carnitine) constitutes 80% of the total carnitine amount. Only the L form is synthesized in tissues, and only this form is metabolically active. Another chemical form of L-carnitine is acetyl-L-carnitine and propionyl-L-carnitine "(26).

History of L-Carnitine

L-carnitine was discovered as a compound isolated from muscle tissue by Russian scientists Gulewitcsh and Krimberg in 1905 and was later named "carnis", meaning meat in Latin (3).

In 1927, L-carnitine was approved as a chemical structure. Professor at the University of Leipzig in 1935. Dr. Strack wrote the first article on carnitine, forming the basis of many years of ongoing studies on the physiological functions of carnitine. In 1952, two researchers Fraenkel and Freidman found that carnitine was the basis for its development in a study in which Tenebrio molitor (flour worm) worked towards the need for vitamins in the metamorphosis phase. Carnitine is named as vitamin BT.

In 1958, Fritz found that carnitine increases the oxidation of fats in mitochondria, and has a great importance in the oxidation of fatty acids (6).

Natural Sources of L-Carnitine

Natural sources of carnitine are found only in the L form. The D form is also produced chemically. In addition, the D-L form also contains half (50%) of the active substance in the D-L form. Carnitine, which is the basic compound for plants, animals and some microorganisms, is found in many nutrients in nature at variable levels. Carnitine contains low amounts of plant-based foods, and animal-based foods are rich in carnitine. L-carnitine does not contain any vegetable or animal fats. In the human body, low levels (20 mg) of L-carnitine are produced naturally in the liver and kidney. Concentrations higher than this are also found in the cardiac muscle and skeletal system muscles (28).

Table 2: Natural L-carnitine contents in some food raw materials (3).

Herbal Content Foods	L-Carnitine (mg/kg)	Foods with Animal Ingredients	L-Carnitine (mg/kg)
Oat	**5**	Fish	**120**
Barley	**7**	Meat	**150**
Wheat bran	**15**	Blood	**10**
Corn	**5**	Feather	**120**
Wheat	**5**	Fish Skeleton	**90**
Soybean	**12**	Meat Bone (%40)	**100**
Grape Seed	**5**	Plasma Protein	**15**
Sunflower Seeds	**5**		
Cotton Seed	**20**		
Hazelnut	**10**		

L-Carnitine Synthesis

Carnitine is synthesized in our body primarily in the liver and kidney, then it can be transferred to other tissues. The carbon chains and nitrogen of carnitine are from L-lysine, and the methyl groups are from methionine. As such, synthesis requires the two essential amino acids, lysine and methionine, as well as vitamin C-B6, iron and niacin. Synthesis is adversely affected by the deficiency of all of these essential nutrients, while the function of L-carnitine is impaired in vitamin B12 deficiency, which requires methionine synthesis (28).

Relationship between L-Carnitine and Diabetes Type II

Carnitine increases the non-oxidative glucose excretion in healthy individuals and diabetic type 2 patients in line with euglycemic hyperinsulinemic conditions, as a result, it increases the insulin effect of carnitine on glycogen storage. Carnitine administration improves insulin-stimulated glucose excretion, thus showing that the metabolite works at the interface between fatty acid metabolism and glucose metabolism (30).

Diabetes Type II and Insulin Resistance

"Diabetes mellitus (DM) is a metabolic disease caused by the insufficiency of insulin secretion of the pancreas or the disruption of the tissue's response to insulin, affecting protein, fat and carbohydrate metabolism. Disruption of the functions of various smooth muscle structures is among the chronic complications of DM. Diabetic patients are generally more prone to cardiovascular system diseases, including micro and macro angiopathy, atherosclerosis, congestive heart failure, and hypertension (25).

Diabetes affects approximately 3% of the world population. The most important symptom of the disease is hyperglycemia. High levels of glucose meet with proteins in the organism and turn into glycosylation, which can be chemically recycled, and this conversion increases in direct proportion to the blood glucose level. The glycosylation created by glucose with collagen or different

long-lived proteins in the walls of blood vessels or interstitial tissues changes into non-reversible glycosylation end products as a result of a series of chemical reactions. This accumulation increases as hyperglycemia continues. Glycosylation end products are microangiopathy, retinopathy, nephropathy, neuropathy etc. that occur in diabetes. It is of great importance in the occurrence of very important complications (22).

Diabetic Nephropathy

There are approximately 151 million diabetes mellitus (DM) patients in the world. Approximately 97% of these are Type 2 DM. Complications of DM are divided into two as microvascular and macrovascular complications. Microvascular complications; retinopathy, nephropathy and neuropathy. Macrovascular complications are coronary heart disease, peripheral vascular disease and cerebrovascular diseases. Diabetic nephropathy (DN) is a major health problem as an increasing number of patients develop end stage renal disease (ESRD). 40% of the newly developed SDBY in the USA is DN. By definition, DN is a positive continuous urine albumin dip in a patient with diabetes, without other kidney diseases, or more than 300 mg of albumin excretion per day. Although DN seems to be a late finding of diabetes, there are physiological, pathological and clinical symptoms before DN. This situation has caused some researchers to think about DN as stages (20).

The pathology of kidney lesions in diabetes type I or type II is similar, hyperglycemia is of great importance in the development and progression of nephropathy in diabetes type I, it mostly occurs as a result of hypertension (HT) or cardiovascular disorders (CVD), nephropathy. It has been determined that nephropathy decreases 10 to 15 years after blood glucose is normalized as a result of a positive pancreas transplantation in people with diabetes type I. The proliferation of HT, hypercholesterolemia, plasminogen activator inhibitor (PAI) together with hyperglycemia is also noteworthy in diabetes type II (11).

Fioretto et.al (10), generally normal or closer to normal glomerular structure was found in people with diabetes type II with microalbuminuria, and similar level of glomerulopathy in people with diabetes Type I.

Diabetes Diagnosis and Evaluation

The diagnostic criteria of the risky group in diabetes are currently being discussed. With the IDF, WHO accepted that all people with fasting blood glucose above 100mg / dl were diagnosed with diabetes. However, as a result of the researches conducted by health planners, after the risk limit in fasting blood glucose being 100 mg / dl included the majority of the population as a risk group, they changed this limit to 110mg / dl in December 2006. In addition, the American Diabetes Association (ADA) still accepts this limit as 100mg / dl. Likewise, all persons with a postprandial blood glucose value between 140 and 99 mg / dl are considered as IGT. As the clinical diabetes limit, an issue that is not open to discussion has emerged above 126 mg / dl in fasting and 200 mg / dl in satiety.

Diabetes symptoms can be explained under two main headings as classical symptoms and less common symptoms.

Classic diabetes symptoms: Polyuria (the production and excretion of large amounts of urine), polydipsia (continuous or habitual drinking more than normal water without thirst), polyphagia (overeating obesity) or loss of appetite, weakness, fatigue, dry mouth, nocturia (nocturia) waking up a lot with a desire to do).

Less common symptoms of diabetes: Blurred vision, unexplained weight loss, persistent infections, recurrent fungal infections, itching (21).

Screening and Diagnosis of Diabetes Type 2

Diagnostic criteria with screening for diabetes in adult society:

Diagnostic criteria with ADA recommended screening; 75 g in people with A1c, fasting plasma glucose (APG), BAG and IGT. It is the second hour OGTT value with glucose. Turkey Endocrinology and Metabolism Association (SEMT) in this manual values in line with the recommendation of the island has been proposed in the form of proof based on common sense. Despite the fact that A1c measurements are among the diagnostic criteria of ADA, it was deemed appropriate from TEMD to carry out the test for screening and diagnosis in our country, when attention is paid to the technical or standardization deficiencies and financial situation. All adults should be evaluated for diabetes type 2 risk according to their demographic or clinical characteristics. In obese or obese (BMI 25 kg / m2), especially in individuals with central obesity (waist circumference> 88 cm in women,> 102 cm in men), since the age of 45, normal test results are also observed once in 3 years, depending on the preference of the person. should be scanned. However, regardless of age, individuals with a BMI of 25 kg / m2, those who have more than one risk factor or who are not pregnant should be investigated more frequently from earlier ages. These are BAG or IGT tests that show that the risk of diabetes and cardiovascular disease increases in the following years when the definitive diagnosis of diabetes is not determined. According to the results of BAG or IGT tests, taking measures to prevent or delay the emergence of diabetes; Accordingly, non-pharmacological treatments such as medical nutrition, exercise therapy, and lifestyle changes should be initiated beforehand **(1).**

Diabetes Type II and Exercise

While alpha cells are not affected by exercise in people with diabetes type 2, an increase in beta cell functioning is detected. Beta cell compliance in people with diabetes type 2 is based on current secretory capacity. Although insulin sensitivity does not change with the HbA1C level, it can be observed (8). Comorbid conditions and decrease in mobility in some people with diabetes type 2 decrease their exercise skills. Glycemic control: Intensity VO2 max 50% to 80% and 3 to 4 times per week, 30 to 60 min. In studies in which physical activities were performed, improvement in HbA1C values was found to be 10% to 20%, especially in diabetic patients with low diabetes and significant insulin resistance (2). Regular cardiovascular exercises (30 to 60 minutes, 3 to 4 times a week, moderate intensity exercise with VO2 max 60% to 75%, 12 weeks or more) corrects glucose levels and protects the person in progress against diabetes type 2 disease (29). Studies have found a decrease in HbA1C level of 0.6% to 0.7%, an increase in insulin sensitivity of 28%, or a decrease in fasting insulin level of 20% in people with diabetes type II of the mild cardiovascular exercise program (4).

As a result of regularly performed resistive exercise (10 to 15 minute sets, 2 to 3 times a week, exercise with light intensity), a decrease in HbA1C level of 0.4 to 0.5% has been determined in people with IGT and diabetes type II (27). With the combination of cardiovascular or resistant exercise programs in type 2 dietic patients, 0.8% decrease in HbA1C, 106% increase in insulin sensitivity and 7% decrease in fasting insulin value were determined (27). Despite resistant exercise, an increase in muscle mass, an increase in

glycogen storage, an increase in insulin-independent glucose transporters and an improvement in glucose control are observed (13).

Discussion and Conclusion

In line with this information in our study, regular exercise and good physical fitness of the individuals significantly prevents the risk of developing type II diabetes and also eliminates the risk factors associated with type II diabetes. An increase in muscle mass of people who exercise regularly, an increase in glycogen storage, an increase in insulin-independent glucose transporters and an improvement in glucose control are also indicators of this. The use of L-carnitine positively affects the course of the disease in people with type II diabetes. The use of L-carnitine in people with type II diabetes increases the non-oxidative glucose excretion in line with euglycemic hyperinsulinemic conditions and consequently increases the insulin effect of carnitine on glycogen storage. In addition, it improves insulin-stimulated glucose excretion, resulting in the metabolite working at the interface between fatty acid metabolism and glucose metabolism.

In conclusion, the use of L-Carnitine at a determined level, together with physical activity and regular exercise under expert control, can be recommended in patients with diabetes type 2.

References

1. American, D. D. Standards of medical care in diabetes. Diabetes Care, 2011; 34 (1):11-61.

2. Bahadır, Ç. T., ve Atmaca, H. Diyabet ve egzersiz. Journal of Experimental and Clinical Medicine ,2012; 20.

3. Baumgartner, M., and Blum, L. Feedstuff. Typical L-carnitine Contents in Feedstuff. Feeds without Animal Meal: is Adequate L-carnitine Provision Stil Safeguarded?, pp:1-5. Lonza Ltd. Muenchensteinerstrasse 38, 1997; CH-4002, Basel.

4. Boule, N. G., Kenny, G. P., Haddad, E., Wells, G. A., and Sigal, R. J. Meta-analysis of the effect of structured exercise training on cardiorespiratory fitness in type 2 diabetes mellitus. Diabetologia, 2003; 46, 1071–1081.

5. Boyce, R. W., Boone, E. L., Lee, A. H., and Cioci, B. W. Physical activity, weight gain and occupational health among call centre employees. Occupational Medicine, 2008;58:238–244.

6. Bremer, J. Carnitine Metabolism and Functions. Phsiological Reviews, 1983; 63 (4):1420-1480.

7. Bulut, S. Sağlıkta sosyal bir belirleyici; fiziksel aktivite. ANKARA: Turk Hij Den Biyol Derg., 2013; 70(4): 205-14.

8. Dela, F., von Linstow, M. E., Mikines, K. J., and Galbo, H. Physical training may enhance beta-cell function in type 2 diabetes. Am. J. Physiol. Endocrinol. Metab.,2004; 287, 1024-1031.

9. Erbaş, O. Deneysel Diyabet Modelleri" Derleme. FNG & Bilim Tıp Dergisi, 2015; 1(1):40-42, doi: 10.5606/fng.btd. 008.

10. Fioretto , P., Steffes , M. W., Sutherland , D. E., and Mauer , S. M. Sequential renal biopsies in IDDM patients: Structural factors associated with clinical progression. Kidney Int.,1995; 48:1929-35.

11. Fioretto, P., Steffes , M. W., Sutherland , D. E., Goetz , F. C., and Mauer , M. Reversal of lesions of diabetic nephropathy after pancreas transplantation. N Engl J Med.,1998; 339:69-75.

12. Genç, A., Şener, Ü., Karabacak, H., ve Üçok, K. Kadın ve Erkek Genç Erişkinler Arasında Fiziksel Aktivite ve Yaşam Kalitesi Farklılıklarının Araştırılması. AFYON: Kocatepe Tıp Dergisi Kocatepe Tıp Dergisi, The Medical Journal of Kocatepe,2011; 12: 145-150.

13. Gulve, E. A. Exercise and glycemic control in diabetes: Benefits, challenges, and adjustments to pharmacotherapy. Physical Therapy, 2008; 88, 1297–1321.

14. Hatice, Ö., ve Hanefi , Ö. Deneysel diyabet oluşturulması ve kan şeker seviyesinin ölçülmesi . Genel Tıp Dergisi, 2007; 17(4):231-236.

15. health.govt.nz. (2019, 12 Haziran). Mınıstry Of Health. Erişim adresi: http://www.moh.govt.nz/moh.nsf/ pagesmh/5535/$File/physical-activity toolkit.doc.

16. Hernandez, S. L., Castro, P. M., Garcìa, R. C., and Crego, A. L. Determination of L- and D-carnitine in dietary food supplements using capillary electrophoresis-tandem mass spectrometry. Food Chemistry, 2010; 120: 921928.

17. Hsing, A. W., McLaughlin, J. K., Zheng, W., Gao, Y.-T., and Blot, W. J. Occupation, physical activity, and risk of prostate canser in Şhanghai, People's Republic of China. Cancer Causes and Control, 1994; 5, 136 - 140.

18. Kafkas, M. E., Açak , M., ve Karademir, T. 12 Haftalık Düzenli Aerobik Ve Direnç Egzersizlerinin Orta Yaş Erkek Ve Kadınların Vücut Kompozisyonları Üzerine Etkisi. NİĞDE: Niğde Üniversitesi Beden Eğitimi ve Spor Bilimleri Dergisi, 2009; Cilt 3, Sayı 3.

19. Katsumata, K., ve Katsumata, Y. Protective effect of diltiazem hydrochloride on theoccurrence of alloxan- or streptozotocin-induceddiabetes in rats. Horm Metab Res, 2006; 1992;24:508.

20. Kurt, M., Atmaca, A., ve Gürlek, A. Diyabetik nefropati. Hacettepe Tıp Dergisi,2004; 35:12-17.

21. Olgun, N., Yalın, H., ve Demir, H. G. Diyabetle Mücadelede Diyabet Risklerinin Belirlenmesi ve Tanılama. The Journal of Turkish Family Physıcıan, 2011; Cilt:2, Sayı:2 :46.

22. Öztürk, F., Gül, M., Ağkadir, M., ve Yağmurca, M. Deneysel Diyabetin Sıçan Testislerinde Meydana Getirdii Histolojik Deiiklikler. T Klin Tıp Bilimleri, 2002; 22:173-178 .

23. Pascoe, W. S., and Storlien, L. H. Inducement by fat feding of basal hyperglycemia in rats with abnormal betacell function. Model for study of etiology and pathogenesis of NIDDM. Diabetes, 1990; 39.226-33.

24. Patel, R., Shervington, A., Pariente, J. A., Martinez-Burgos, M. A., Salido, G. M., and Adeghate, E. Mechanism of exocrine pancreatic insufficiency in streptozotocininduced type 1 diabetes mellitus. Ann N Y Acad Sci., 2006; 1084:71-88.

25. Rao, B. K., Kesavulu, M. M., Giri, R., and Rao, C. A. Antidiabetic and hypolipidemic effects of Momordica cymbalaria Hook. Fruit powder in alloxan-diabetic rats. . J Ethnopharmacol , 1999; 67:103-9.

26. Seline, K., and Johein, H. The determination of L-carnitine in several food samples. Food Chemistry, 20007; 105: 793-804.

Snowling, N. J., and Hopkins, W. G. Effects of different modes of exercise training on glucose control and risk factors for complications in type 2 diabetic patients: a meta-analysis. Diabetes Care, 2006; 29, 2518–2527.

Taşbozan, O., ve Gökçe, M. A. L-Karnitin Ve Akuakültürde Kullanımı. Türk Sucul Yaşam Dergisi ,Turkısh Journal Of Aquatıc Lıfe, 2007; Yıl: 3-5, Sayı: 5-8: 694-703.

Tuomilehto, J., Lindstrom, J., Eriksson, J. G., Valle, T. T., Hamalainen, H., Illanne-Parikka, P., and Uusitupa, M. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. N. Engl. J. Med., 2001; 344, 1343–1350.

Türkay, İ. K., ve Atay, E. Düzenli Egzersizle Birlikte Kullanılan L-Carnitine'nin Genç Obez Ratların Kilo Vermelerine Etkisi. Spor Eğitim Dergisi, 2019; 3(1), 93-99.

Türkay, İ. K., ve Başalp, A. Effect of l-carnıtıne used in regular exercıse in elderly obesıs rats. Turkish Journal of Sport and Exercise, 2019; 21(1), 74-77.